
Food and Nutrition: The Good, The Bad, and The Ugly

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THE 19TH CENTURY IN THE UNITED STATES WAS A PERIOD OF GREAT EXPANSION OF population and of cities and territory. With the establishment of the railroad and enhanced food-preservation technologies, a variety of food products soon became available across the country. By the end of the century, markets began to replace the personal or local farm as the primary source of food attainment (Williams, 2006). New techniques in agriculture and food preservation were developed to meet new demands for greater food choices at modest prices. In the 1890s, Wilbur O. Atwater at the USDA established the first compositional and requirement tables for food (Welsh et al., 2002). During the same time period, the US government expanded research into nutrition and food safety for the military (Friedl and Hoyt, 1997). In part, as a consequence of the above, by the early 1900s a set of demands that met the needs of the average consumer, public health officials, government entities, and the food industry was established. These demands were, and continue to be, for foods and diets that are safe, nutritious, well balanced, and modestly priced, while affording those in industry a profit. Although initially the primary demands on the food industry were that the products they provided be safe and reasonably priced, the expectation today is that foods we consume will also protect against a wide variety of age-related diseases. Thus, changing concepts in the expectations of food in the past century have moved beyond the reduction of well-recognized nutritional deficiencies (*e.g.* scurvy, rickets, and pellagra) to that of food providing “optimal health” (Figure 1).



Figure 1. The changing expectations from a healthy diet: From prevention of essential nutrient deficiencies to achieving optimal health.

It is important to note that consistent with these new expectations of diet by the public, a major part of the rationale driving the development of current US and Canadian Dietary Reference Intakes (DRIs) is that nutrient intakes should ideally be set at levels that reduce the risk for select chronic diseases, such as diabetes, heart disease and cancer (IOM, 1997; Chung *et al.*, 2010). This expanded the mission of public-health policy from setting nutrient levels to prevent deficiencies that cause well-defined diseases to the establishment of dietary recommendations for the prevention of chronic disease states that are multifactorial in etiology, and for which established biomarkers are not yet well defined (Chung *et al.*, 2010; IOM, 2010). As part of the DRI process, in addition to the identification of the adequate intakes (AI) and recommended dietary allowances (RDA) for essential nutrients, when possible the committees also identify tolerable upper intake levels (UL) for these nutrients, which are defined as the amount of the nutrient that can be consumed on a daily basis with no evidence of harm. Inherent to the UL concept is that there is a U-shaped curve for any essential nutrient. While the concept of U-shaped curves and the importance of ULs are well accepted by nutritionists, how the general public will interpret them is unknown. While common in the drug industry, in general the agricultural industry at large, and the food industry specifically, has minimized discussions concerning risks and benefits. A reasonable question is whether this is an issue that food companies should address in the near future. For the food industry, this new

goal of the DRIs can be viewed as a huge opportunity or a daunting challenge. We would submit that the DRIs represent a major step forward in nutrition sciences; how the food industry will use them and communicate the potential value of the DRIs to the general public is yet to be determined. Below, we present examples where foods have been modified to reduce the risk of select diseases, and we discuss some of the potential benefits and hazards that can occur when this approach is taken.

THE GOOD: EARLY NUTRITION SUCCESSES

In the past 100 years, a number of public-health agencies, and later the government, had numerous significant successes with respect to nutrition and health and the prevention of well-recognized primary nutritional deficiency disorders, by working in concert with the food industry. An example of this in the United States is the addition of iodine to table salt in 1924 to prevent goiter. Iodized salt was initially limited to the state of Michigan, as the Michigan State Medical Society was first to work with their state's salt producers to reduce industry concerns and advance the technology to bring this product to the public. Subsequent data showing a successful decline of goiter influenced the rest of the industry to iodize salt throughout the country, lest they lose a market opportunity. By no more than a decade later, iodine deficiency in the United States had been largely eliminated as a public health problem (Backstrand, 2002; Bishai and Naluba, 2002). Although this is a clear success story for the food industry, with respect to the general public there is little appreciation of the critical role that iodized salt has played in the prevention of iodine-deficiency disorders. Unfortunately, in part as a consequence of the current trend for salt avoidance, there are increasing reports that marginal iodine deficiency may be reemerging as a public health issue (Perrine *et al.*, 2010; Tayie and Jourdan, 2010). How health agencies and food companies might deal with the seemingly conflicting messages of the need to increase one's iodine intake, as well as the need to reduce salt intake, is at present unclear. It is worth noting that the potential problem of iodine deficiency could be further amplified if individuals, in a desire to use more "natural products," elect to use sea salt in place of iodinated table salt, as the former typically contains only trace amounts of iodine (Dasgupta *et al.*, 2008).

The medical community "encouraged" salt iodization whereas industry initiated the establishment of vitamin-D fortification. Rickets was a common childhood disorder in the northeast, with 339 associated deaths reported in the United States in 1933 (Backstrand, 2002). Prior to isolation of vitamin D to combat the disease, a variety of products was available on the market including irradiated milk, cod-liver oil preparations, and milk from yeast-fed cattle. With the isolation of vitamin D, the dairy industry was able to begin to fortify milk by 1932. A combination of industry advertising and promotion by the American Medical Association raised awareness of the preventative benefits of consuming vitamin-D-fortified milk (Bishai and Naluba, 2002).

While rickets and goiter were considered substantial health issues by the general public, beri beri and pellagra were of less concern. These micronutrient deficiencies were not addressed until 1941, when President Roosevelt convened the Committee on Food and Nutrition of the National Research Council for a National Nutrition Conference for

Defense. At this conference the first RDAs were presented. The committee also expressed concerns with the lack of regulatory oversight with regard to fortification of foods, and established guidance for fortification under the authority of the FDA. The FDA established standards for flour enrichment with iron, thiamin and niacin in 1942, and riboflavin in 1943 (Backstrand, 2002). In 1942, the US army began purchasing enriched flour only, and by the end of the 1940s several states enacted laws mandating flour enrichment (Bishai and Nalubola, 2002). For the most part, the above food-fortification strategies were widely successful, significantly reducing the frequency and severity of what were once common nutritional deficiency diseases throughout the United States.

Regrettably, the above public-health successes have largely been forgotten, as has the critical role that the food industry has played in the prevention of these nutritional deficiency diseases. One often hears that diets 100 years ago were typically better than they are today, and that “natural foods” are typically superior to the modified foods one finds in today’s grocery stores. While these views are clearly flawed, less evident are the actions that are needed to correct these misperceptions. Education campaigns in this area could have multiple benefits, ranging from a greater awareness of the historical role food companies have had in improving the general public health, to potentially creating an environment where the public is more responsive to the concept that, through relatively simple food modifications (fortification, raw-ingredient sourcing, food processing, *etc.*), further marked improvements in the health of the general population are likely to be achieved. It is reasonable to suggest that a greater acceptance of this concept would help agriculture and the food industry meet, in a timely fashion, many of the objectives that are shown in Figure 1. However, it must be stressed that the last objective in Figure 1 (a condition of “optimal health”) cannot realistically be achieved through diet alone. Although most individuals accept this point, the extent to which they think that diet is the key to optimal health varies considerably. This variation is due in part to how one defines the phrase “optimal health.” Is it a sense of good health and well being, a reduction in the initiation and progression of certain chronic diseases, the achievement of one’s genetic potential, or the ability to play tennis and win at the age of 80? Depending on how the phrase is defined, the extent to which the food industry can help the general population meet this goal varies tremendously. Equally important, industry needs to help manage expectations regarding how quickly we think significant specific changes in health through diet modifications should occur. For example, given what is already known concerning the influence of several nutrients on vascular function, most would agree that reductions in blood pressure across the general population could be achieved through some relatively simple diet modifications. However, there is a dearth of information on how select nutrients might influence one’s risk for many age-related chronic diseases, such as dementia. Thus, measurable progress in this area is bound to be slower.

THE GOOD: “LET FOOD BE THY MEDICINE, LET THY MEDICINE BE THY FOOD”

Hippocrates told his students 2,500 years ago that food can heal through a proper diet (Halsted, 1998). To this day, nutrition research is still focused on how diet can reduce

risk of onset and progression of a number of chronic diseases. However, a major problem facing the food industry with respect to the design of “healthy foods and diets” is that multiple factors can influence an individual’s nutrient needs. These factors include

- age,
- sex,
- genetic background,
- reproductive status,
- lifestyle habits,
- presence of disease(s), and
- general environment.

Clearly, on a practical basis, foods, much less diets, cannot be specifically tailored to each individual’s needs. While this is not a major issue, if one is simply producing foods that are good for one’s general health, it is an issue if the food, and specific components in it, is being touted as a means of reducing the risk for select diseases or health conditions. Although this concept is well accepted in medicine, the extent to which it can complicate dietary recommendations for the general public has received surprisingly little attention. This is, in part, understandable, given that many diet recommendations in the past were relatively generic (rich in plant foods and low in salt and saturated fat, *etc.*), but in the future this will become a greater issue as we increasingly view food and diet as tools for reducing the risk for a variety of diseases or health conditions.

An example of the above is the relatively recent folic-acid fortification of cereal products in the United States and Canada. The target population for this diet modification was pregnant women—to reduce the risk of children being born with neural tube defects (NTDs)—yet the entire population is affected by it. Furthermore, it is thought that the pregnant women who will benefit most are those who have genetic polymorphisms that affect folate absorption and metabolism (Blom, 2009), therefore, the subset of women benefitting from folate supplementation might be quite small. On the other hand, folate-fortification programs in the United States and Canada have been very successful with respect to the primary goal, a reduction (approximately 50%) in the incidence of infants born with NTDs (De Wals *et al.*, 2007; Obican *et al.*, 2010). The above outcome can certainly be heralded as an excellent example of the successful use of food as a means to reduce the risk for a severe health complication, yet others have argued that widespread folate fortification might increase the risk of other health complications, including the development of some cancers (Lucock and Yates, 2009). At present, this is still an issue of debate, although current data suggest an increase in cancer attributable to the folate fortification program has not occurred. While the authors of the current paper support folate-fortification programs, the question that needs to be addressed is, to what extent should the potential risks and benefits of food-fortification programs, such as that for folate, be communicated to the general public? In a similar vein, to what extent, if any, does the food industry have a responsibility to provide the public with a variety of foods that contain various amounts of select nutrients?

It would be wrong to dismiss the food folate-fortification issue as unique. Similar issues have been raised with respect to iron fortification of foods, and more recently vitamin D. Major concerns were once raised that iron fortification could present a significant health challenge to individuals with hereditary hemochromatosis. With respect to vitamin D, during the past five years increasing attention has been given to the idea that typical dietary vitamin-D intakes are suboptimal (Holick, 2010). This change in thinking by some experts has come about due to recent data suggesting that vitamin D has positive physiological actions above and beyond bone health. Indeed, some experts are arguing that vitamin-D intakes should be higher than the UL that was set by the Food and Nutrition Board in 1997 (IOM, 1997). The current paper is not the place for a debate on the relative pros and cons of increasing dietary vitamin-D recommendations, but rather we cite it as an example of where new expectations of a nutrient (*e.g.* high levels of vitamin D have been postulated to reduce the risk for colon cancer) may significantly influence current food-fortification programs. The key question that we ask here is, to what extent should the general public be involved, or aware, of this debate? Specifically, to what extent should the public be informed of potential risks, as well as potential benefits, of a marked increase in vitamin D in commonly consumed foods? Assuming that we continue to develop new foods (changes in raw product sources, processing, formulation, *etc.*) that are aimed at substantially reducing the risk for select diseases in some population groups, the probability that some adverse effects will be associated with their use in other populations will undoubtedly increase. How do we communicate this risk, and who should be responsible for the communication?

THE GOOD: EVOLUTION OF DIET RECOMMENDATIONS, AND OUR EXPECTATIONS OF FOOD

During the past decade there has been a resurgence in the idea that shifts in our diet can translate into marked changes in our risk for certain diseases. Illustrative is the increasing research on phytochemicals that are thought to have vascular health properties. Observational studies have suggested that large intakes of fruits and vegetables (5–8 servings per day) are associated with reduced risk of cardiovascular disease (Liu *et al.*, 2000; Joshipura *et al.*, 2001; Dauchet *et al.*, 2006); further analyses have shown even stronger associations with certain foods and specific phytochemicals (Erdman Jr. *et al.*, 2007; Mink *et al.*, 2007). For example, interventional studies have suggested that the consumption of foods high in specific subclasses of the large flavonoid family, the flavanols and procyanidins, can improve a number of measures of vascular health, including vascular and platelet reactivity, and markers of inflammation (Holt *et al.*, 2006; Selmi *et al.*, 2006; Heiss *et al.*, 2010) (Figure 2). Intake of select purified phytochemicals, such as the flavanol (-)-epicatechin, provided in similar amounts to those found in food, has been shown to have positive vascular effects (Schroeter *et al.*, 2006). The type of work described above is critical as it is well established that the flavonoid and flavanol contents and profiles in foods can greatly vary depending on the agricultural and food processes from which the food product originated. Illustrative is that the effects of food processing might be especially important with respect to the availability of bioactive (-)-epicatechin, as it can epimerize with heating

and alkalization to (-)-catechin (Gotti *et al.*, 2009; Ritter *et al.*, 2010). While the extent to which a shift in the flavanol profile of a food (*e.g.* from (-)-epicatechin to (-)-catechin) might alter its health effects is still an issue of debate, this is an example of the new way that phytochemicals in foods are being investigated. The recent work with flavanol- and procyanidin-rich foods is also important as the consumption of such foods has been reported to improve the vascular health even of diabetics and patients with coronary artery disease (Heiss *et al.*, 2010). Taken together, this body of work is just one example of how a food product that is well characterized for its nutrient content can produce robust and consistent changes in specific biomarkers; and it is demonstrative of how current research on nutrition has moved towards the Institute of Medicine’s goal of defining nutrients that will slow or prevent the onset of chronic disease (Chung *et al.*, 2010). Clearly, evidence is accumulating that food can, indeed, be part of one’s medicine.

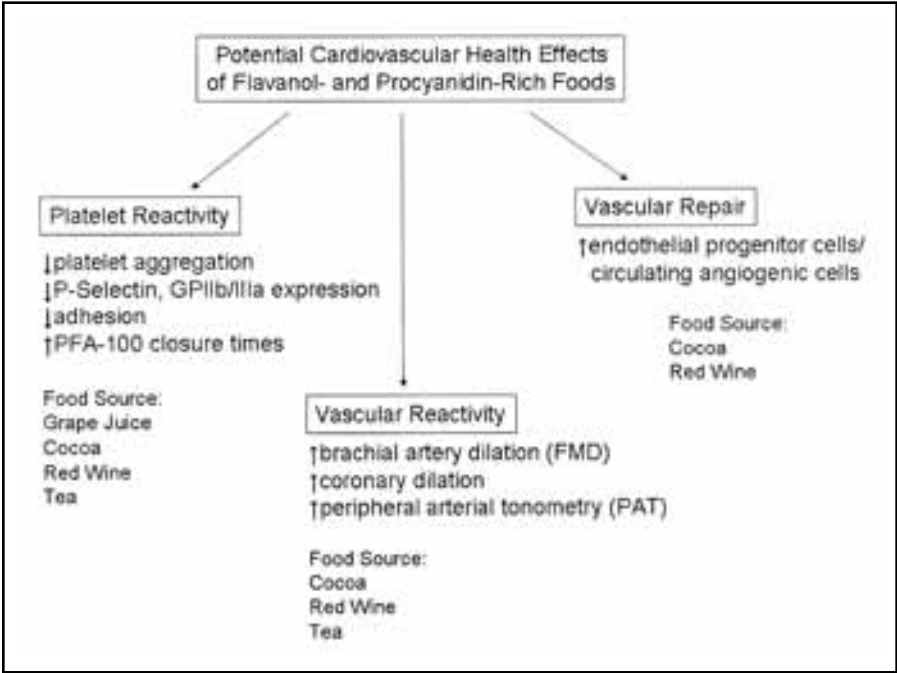


Figure 2. Reported cardiovascular health effects after intake of indicated foods that are rich in flavanols and procyanidins (see Holt *et al.*, 2006; Heiss *et al.*, 2010).

THE BAD: HOW GOOD IS OUR FOOD?

A common question from the lay public is: are our diets better today than they were 50 or even 100 years ago? As is outlined above, a critical review of the facts shows that the answer to this question is an easy, “Yes.” However, despite the many examples that

show our diets are better today, many consumers feel otherwise. We would submit that an understanding of this divergence of views is critical as we seek to improve popular perception of the agricultural industry in general, and the food industry more specifically. As discussed above, we suggest that the public's sometimes negative view of the food industry as it relates to their provision of "nutritious foods" is due in part to an evolution in our thinking as to what constitutes a healthy diet. A hundred years ago, the concept that our diet could be a key factor in the prevention, much less the treatment, of numerous disease states received minimal attention. Today, diet is viewed increasingly as a key player in the initiation, progression, and treatment of numerous diseases. As we change expectations of our diets, it should not be surprising that they are at times found wanting. As discussed above, an example of this is our limited ability at the present time to define the multiple factors that contribute to the positive vascular health effects of diets rich in plant foods. A predictable consequence of this is that intervention trials in which the effects of select plant foods are studied on biomarkers thought to reflect vascular health will, at times, be negative. When the information from negative trials is not carefully presented, it can lead to cynicism in the public, and fuel the belief that some foods are not as beneficial as we have preached. On the positive side, the above issue is one that can be managed with appropriate educational campaigns. However, on the negative side, for the most part, the agricultural industry has not taken a leadership role in the development of such campaigns.

Food safety is another area where there can be striking differences of opinion between the lay public and health professionals. While the vast majority of experts in the broad field of food safety would endorse the statement that our food supply is safer today than it was 50 years ago, we increasingly hear concerns over food safety from the general public. These concerns span a wide range of issues from the potential risks of pesticide residues on fruits and vegetables, to genetically modified foods, to the increasing use of nanomaterials in food products (Borchers *et al.*, 2010). In the absence of strong educational campaigns, unease over food safety will only increase. It is imperative that we find ways to communicate to the public food-safety messages that can, at times, be complex. An example of this problem can be drawn from current ongoing debates concerning pesticide residues, where distinctions are typically not made between variables such as exposure versus risk. As a consequence, one often hears the argument that organically grown fruits and vegetables are "healthier" than conventional counterparts. While there are a number of reasons why one might prefer organically grown foods, the fear that conventional grown crops are unsafe should not be one of them. Again, proactive educational campaigns are needed.

Another major issue facing agriculture and the food industry today is an increasingly prevalent opinion that the food industry is primarily driven by a quest for profit, even when it is to the detriment of the health of the general public. Illustrative of this, a commonly heard theme in the United States is that irresponsible food companies are largely to blame for the current obesity epidemic (Parloff, 2003; Ludwig and Nestle, 2008). This claim is often based on the idea that many of the low-cost foods available in the marketplace today have little to offer in the way of "good nutrition," but rather are simply inexpensive sources of energy (Drewnowski and Darmon, 2005). It has been argued that

these nutrient-poor low-cost foods are being disproportionately consumed by individuals in lower socioeconomic groups, with the result that these individuals are at a heightened risk for nutritional deficiencies, as well as numerous diseases including obesity and diabetes (Drewnowski and Darmon, 2005; Drewnowski, 2009). At its worst, one increasingly sees and hears terms, such as “toxic food corridors,” being used to describe how components of the food industry are in effect a major cause of the obesity epidemic. Clearly, this is an area where the food industry again needs to be part of coordinated educational campaigns. The message that the “food industry” is putting out “toxic foods” is one that demands urgent attention. While some food industries might view this issue as one that only concerns fast-food restaurants, this is not the case. An example of how the concept of toxic foods can take hold, beyond the issue of obesity, can be drawn from the “*trans* fats” story. In the early 1900s, it was discovered that liquid oils could be hydrogenated to form *trans* fatty acids, and *trans* fat became the first man-made fat to be widely used in the food supply. In the 1950s, *trans* fats were viewed by many, including the American Heart Association, as a positive factor in the diet. However, in the early 1990s a series of papers suggested that diets high in *trans* fats might be a risk factor for vascular disease. Although the extent to which *trans* fats are causal in the initiation and progression of vascular disease is still a subject of debate, in 2003 the FDA required *trans* fat labeling on the *Nutrition Facts* label. In 2006, New York City banned the use of *trans* fats in restaurants, and multiple other cities have since followed their lead (Okie, 2007). Whether or not the removal of *trans* fats from the food supply will have a measurable effect on the risk for vascular disease in the general population is not the issue here. Rather it is that the food industry was widely portrayed as being a culprit in the story, adding *trans* fats to foods in order to increase their bottom line. That *trans* fats were initially viewed by many public health officials as being good is a part of the story that was largely ignored, and to this day many view *trans*-fat-containing foods as toxic.

THE UGLY? CHANGING EXPECTATIONS OF FOOD: EVOLUTION OF BIOMARKERS.

A major problem in the food industry is that health claims are often made for products on the basis of minimal or no data. Recently, the public has been exposed to one story in the media after another in which food companies are pilloried for making unsubstantiated health claims about their products. This is a problem that is bound to increase, as the demands for health-promoting products will certainly expand as individuals look to their diets as a means of reducing their risks for the development, and treatment, of select chronic diseases. While it is easy to make the argument that food companies should provide at least some data in support of their claims that their products do indeed have health-promoting effects, far more contentious is the question of how extensive this data base should be. In contrast to the pharmaceutical industry, intellectual property, as it relates to potentially newly discovered health benefits of common nutrients in the food supply, is hard to define. Historically, this has not been an issue, but if we increasingly turn to diet (and select foods) as a form of medicine, this is an issue that merits attention. In this regard, a National Academy of Sciences Institute of Medicine committee recently pub-

lished a monograph entitled *Evaluation of Biomarkers and Surrogate Endpoints in Chronic Disease* (IOM, 2010) that deserves special attention. This comprehensive report provides a number of observations and recommendations concerning the use of biomarkers in nutrition and disease studies. In Figure 3, we highlight three of these recommendations. On the surface all are reasonable, but if they were to be implemented it could potentially have a chilling effect on research in the area of functional foods. Given the low costs of food relative to pharmaceuticals, the expenditure involved in conducting studies according to these recommendations would in most cases be prohibitive. Therefore, there is a real risk that many food companies will scale back their research efforts on ways to improve the “nutritional value” of foods if they perceive no competitive advantage to this type of work. A conundrum facing the general agricultural industry, and more specifically the food industry, is how, from an economic perspective, private companies can justify the development of new foods that substantially improve human health. We would submit that it is imperative that this issue is addressed with alacrity, for if it is not, there is a real concern that many in the food industry will reduce their efforts with respect to the future development of impactful health-promoting foods.

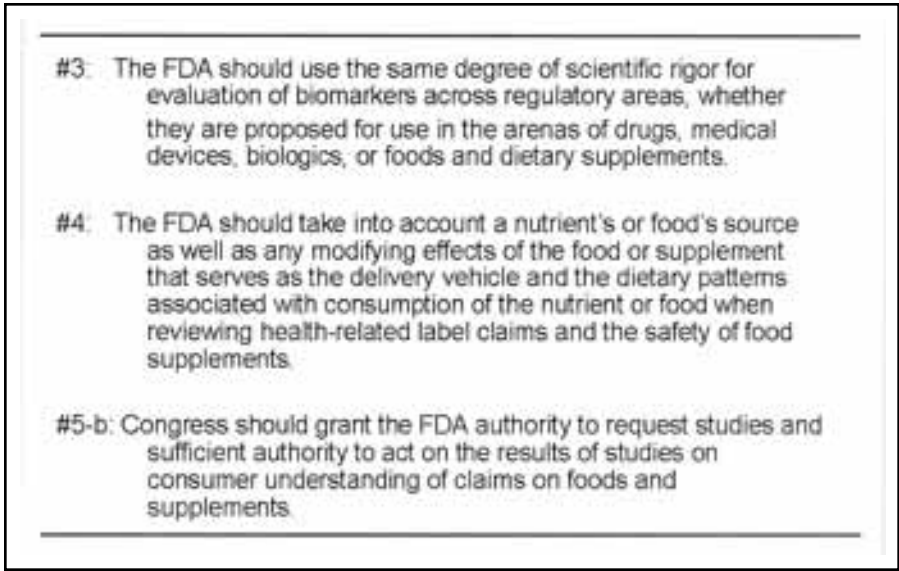


Figure 3. Biomarker evaluation process recommendations (IOM, 2010)

CONCLUSION

The concept that one's health is in part dictated by diet is well recognized. Regrettably, the focus of too many discussions in this area is often on the putative negative effects of “bad diets” and “bad foods,” rather than on the identification of diets and foods that may confer significant positive health effects. There is a clear need for the development

of new educational programs that not only inform the public about the potential health benefits of foods, but that communicate, in an easy-to-understand way, the principles of benefit-risk analysis. The agricultural industry in general and the food industry specifically are poised to make significant new advancements in the generation of what might be viewed as revolutionary health-promoting foods; after 2,500 years we are getting closer to meeting Hippocrates's challenge.

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